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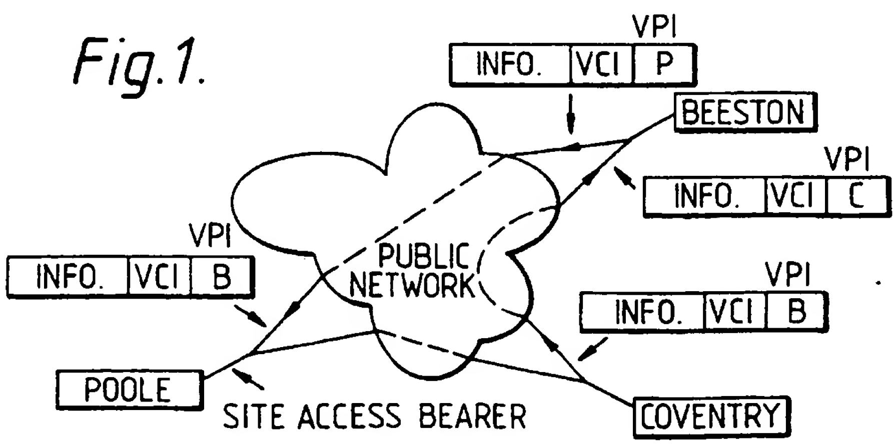
(54) **ATM Network addressing**

(57) Addressing problems in Virtual Private Networks using ATM/Cell-Relay based on Permanent Virtual Circuits in the public network and a movable boundary between the Customer Premises Equipment and the public network are disclosed.

In a corporate network using Asynchronous Transfer Mode (ATM) having two or more site networks linked by a public ATM network using Permanent Virtual Channels (PVCs), the corporate network provides a connectionless service between any pair of terminal ports addressed using only the Virtual Path Identifier field (VPI) and the Virtual Channel Identifier field (VCI) of the CCITT recommended ATM cell format, the full 48 octets of the Information field being transported between the terminal ports with no overhead imposed by the ATM layer of the network.

The VPI and VCI fields at all terminal ports may together carry the destination address and the source address for a communication the network being divided into sub-networks where each sub-network uses a part of the source and destination address to identify a terminal port within a sub-network and the remainder of the source and destination address is used to identify the sub-network.

Fig.1.



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

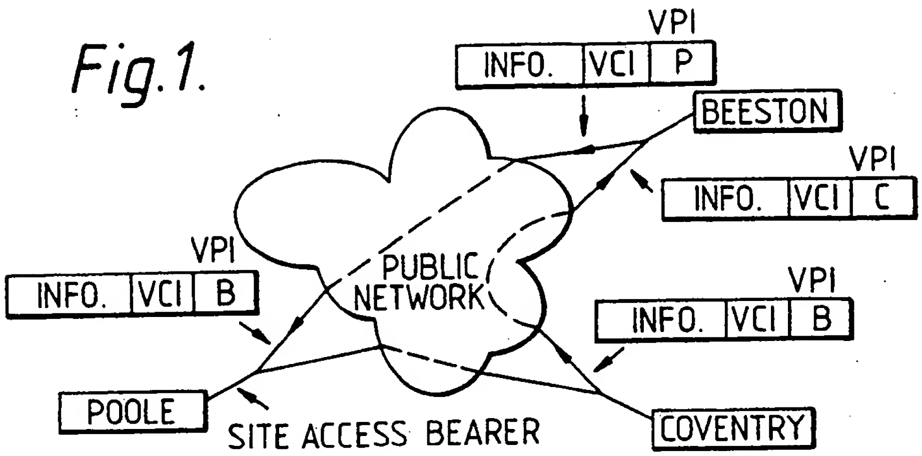


Fig.2.

ATM CELL HEADER FORMAT
USER-NETWORK INTERFACE (UNI)

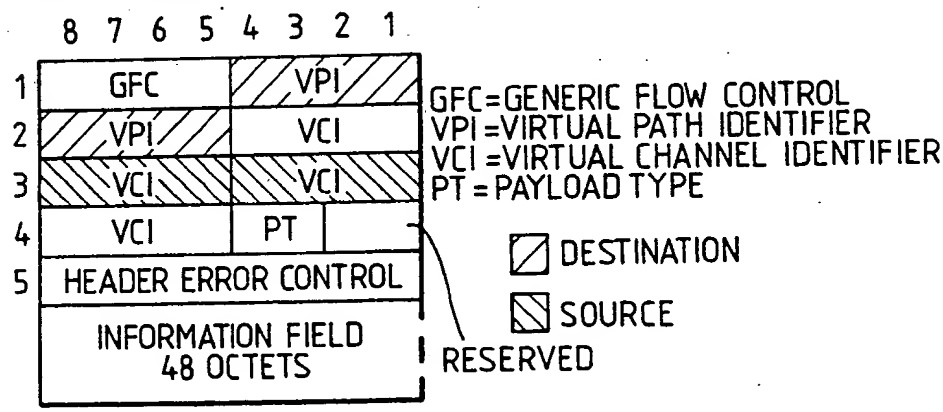


Fig.3.

ATM CELL HEADER FORMAT
NETWORK-NETWORK INTERFACE (NNI)

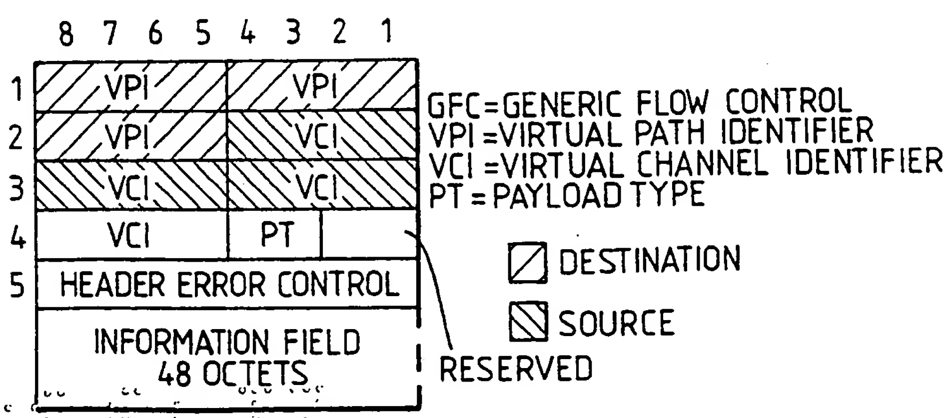


Fig.4.

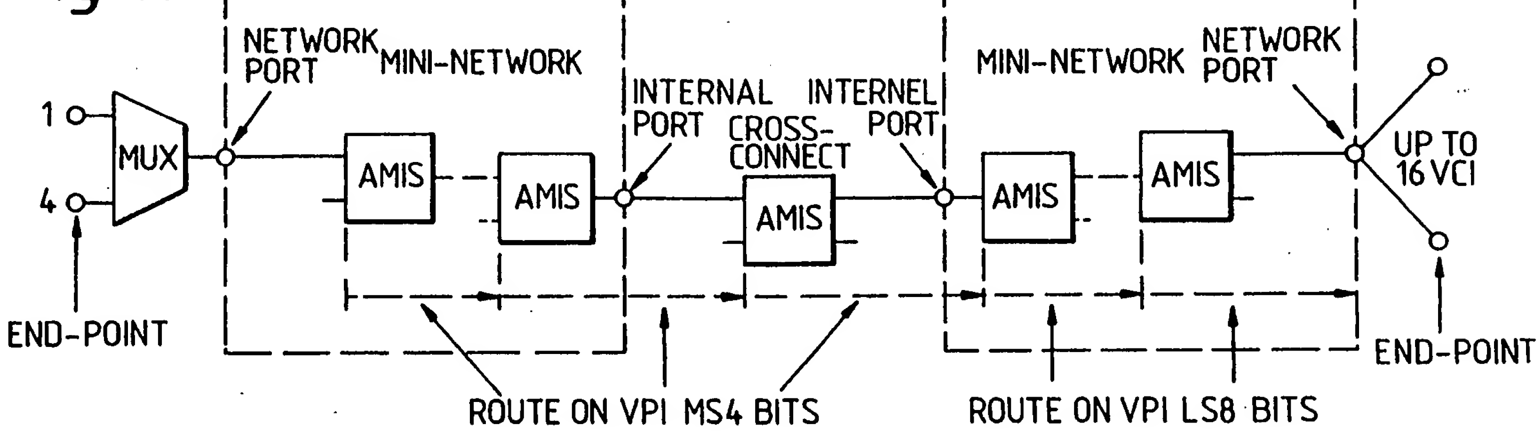

1
4
MUX
END-POINT
NETWORK PORT
MINI-NETWORK
AMIS
AMIS
INTERNAL PORT
CROSS-CONNECT
AMIS
INTERNEL PORT
MINI-NETWORK
NETWORK PORT
AMIS
AMIS
UP TO 16 VCI
END-POINT
ROUTE ON VPI MS4 BITS
ROUTE ON VPI LS8 BITS

Fig.5.

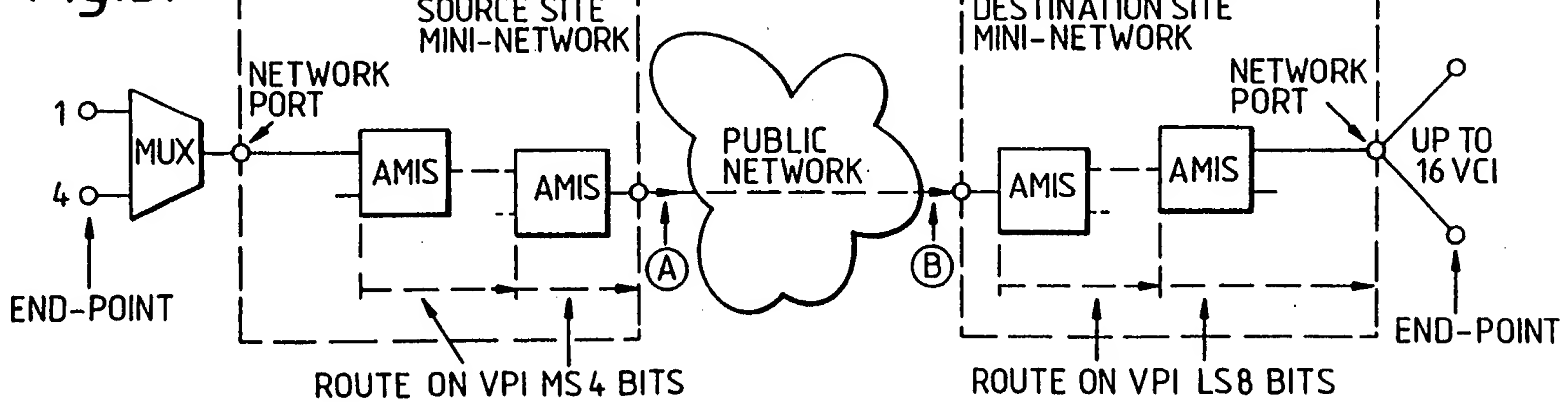

1
4
MUX
END-POINT
NETWORK PORT
SOURCE SITE MINI-NETWORK
AMIS
AMIS
A
PUBLIC NETWORK
B
DESTINATION SITE MINI-NETWORK
NETWORK PORT
AMIS
AMIS
UP TO 16 VCI
END-POINT
ROUTE ON VPI MS4 BITS
ROUTE ON VPI LS8 BITS

Fig. 6.

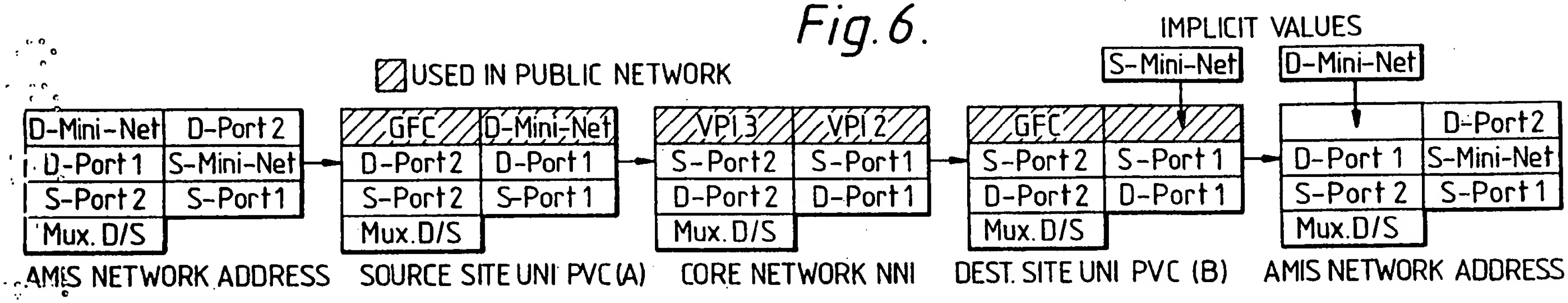

USED IN PUBLIC NETWORK
IMPLICIT VALUES
S-Mini-Net
D-Mini-Net
D-Mini-Net
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
AMIS NETWORK ADDRESS
GFC
D-Mini-Net
D-Port 2
D-Port 1
S-Port 2
S-Port 1
Mux. D/S
SOURCE SITE UNI PVC (A)
VPI 3
VPI 2
S-Port 2
S-Port 1
D-Port 2
D-Port 1
Mux. D/S
CORE NETWORK NNI
GFC
S-Port 2
S-Port 1
D-Port 2
D-Port 1
Mux. D/S
DEST. SITE UNI PVC (B)
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
AMIS NETWORK ADDRESS

Fig. 7.

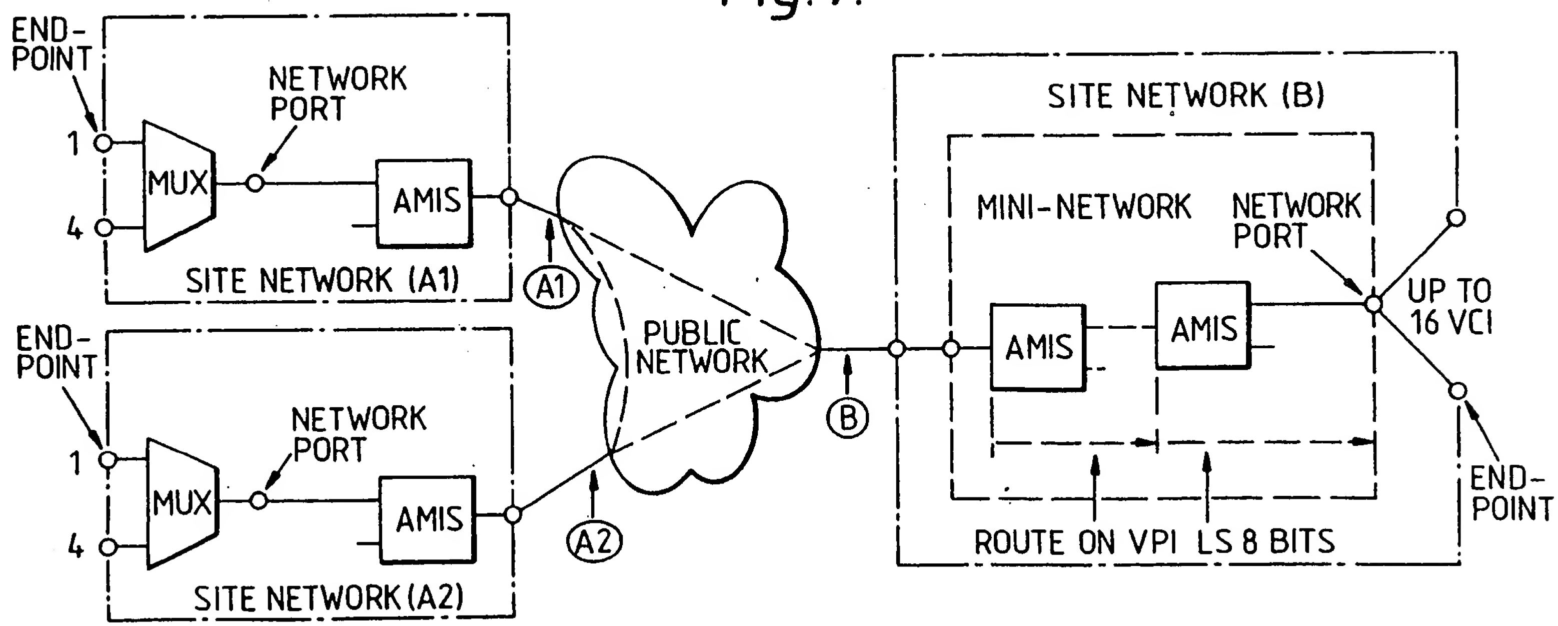

END-POINT
1
4
MUX
NETWORK PORT
AMIS
SITE NETWORK (A1)
END-POINT
1
4
MUX
NETWORK PORT
AMIS
SITE NETWORK (A2)
A1
A2
PUBLIC NETWORK
B
SITE NETWORK (B)
MINI-NETWORK
NETWORK PORT
AMIS
AMIS
UP TO 16 VCI
END-POINT
ROUTE ON VPI LS 8 BITS

Fig. 8.

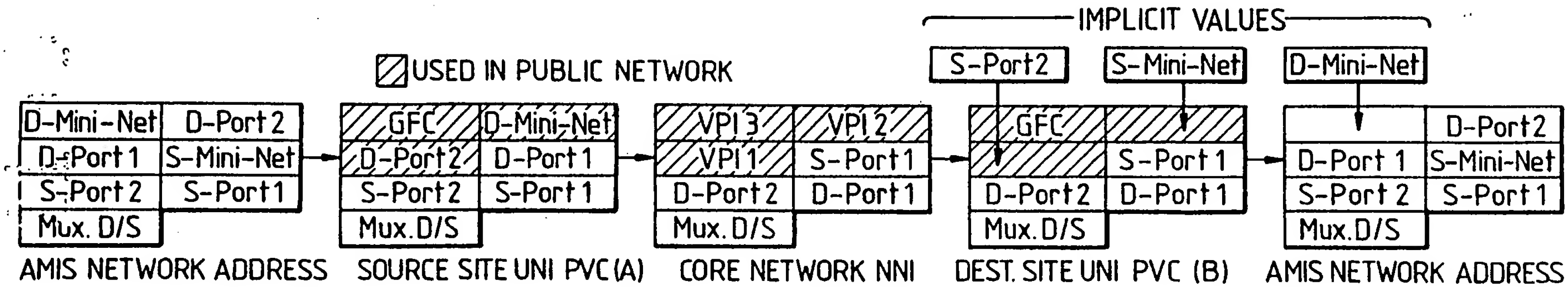

IMPLICIT VALUES
USED IN PUBLIC NETWORK
S-Port2
S-Mini-Net
D-Mini-Net
D-Mini-Net
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
GFC
D-Mini-Net
D-Port 2
D-Port 1
S-Port 2
S-Port 1
Mux. D/S
VPI 3
VPI 2
VPI 1
S-Port 1
D-Port 2
D-Port 1
Mux. D/S
GFC
S-Port 1
D-Port 2
D-Port 1
Mux. D/S
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
AMIS NETWORK ADDRESS
SOURCE SITE UNI PVC (A)
CORE NETWORK NNI
DEST. SITE UNI PVC (B)
AMIS NETWORK ADDRESS

Fig. 9.

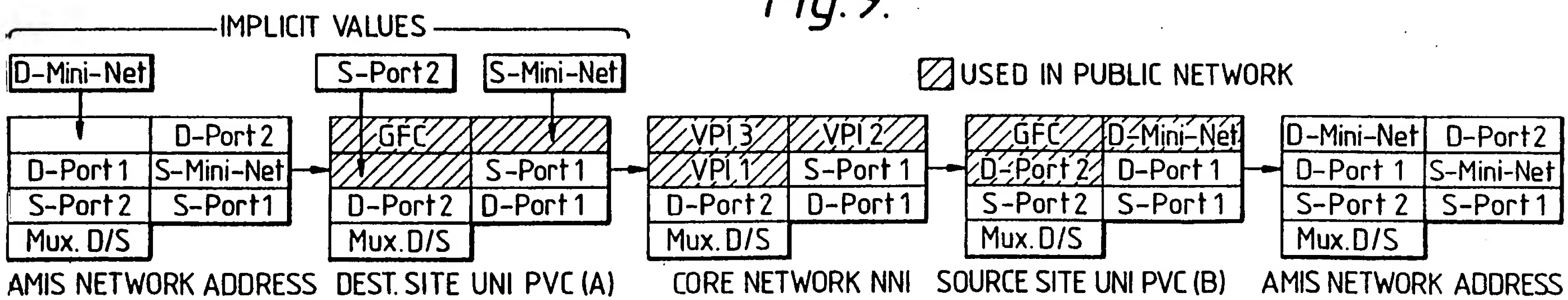

IMPLICIT VALUES
USED IN PUBLIC NETWORK
D-Mini-Net
S-Port 2
S-Mini-Net
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
GFC
S-Port 1
D-Port 2
D-Port 1
Mux. D/S
VPI 3
VPI 2
VPI 1
S-Port 1
D-Port 2
D-Port 1
Mux. D/S
GFC
D-Mini-Net
D-Port 2
D-Port 1
S-Port 2
S-Port 1
Mux. D/S
D-Mini-Net
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
AMIS NETWORK ADDRESS
DEST. SITE UNI PVC (A)
CORE NETWORK NNI
SOURCE SITE UNI PVC (B)
AMIS NETWORK ADDRESS

Fig.10.

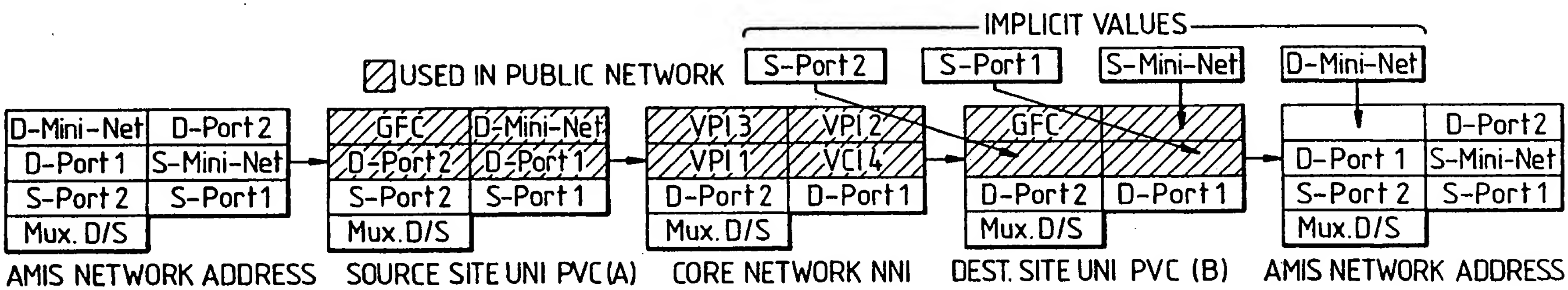

IMPLICIT VALUES
USED IN PUBLIC NETWORK
S-Port 2
S-Port 1
S-Mini-Net
D-Mini-Net
D-Mini-Net
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
GFC
D-Mini-Net
D-Port 2
D-Port 1
S-Port 2
S-Port 1
Mux. D/S
VPI 3
VPI 2
VPI 1
VCI 4
D-Port 2
D-Port 1
Mux. D/S
GFC
D-Port 2
D-Port 1
Mux. D/S
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
AMIS NETWORK ADDRESS
SOURCE SITE UNI PVC (A)
CORE NETWORK NNI
DEST. SITE UNI PVC (B)
AMIS NETWORK ADDRESS

Fig.11.

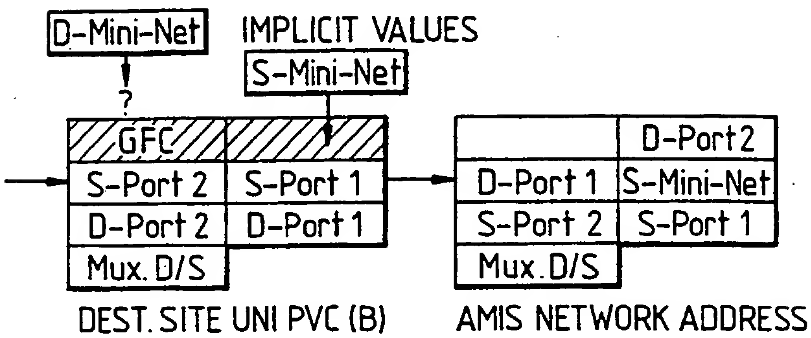
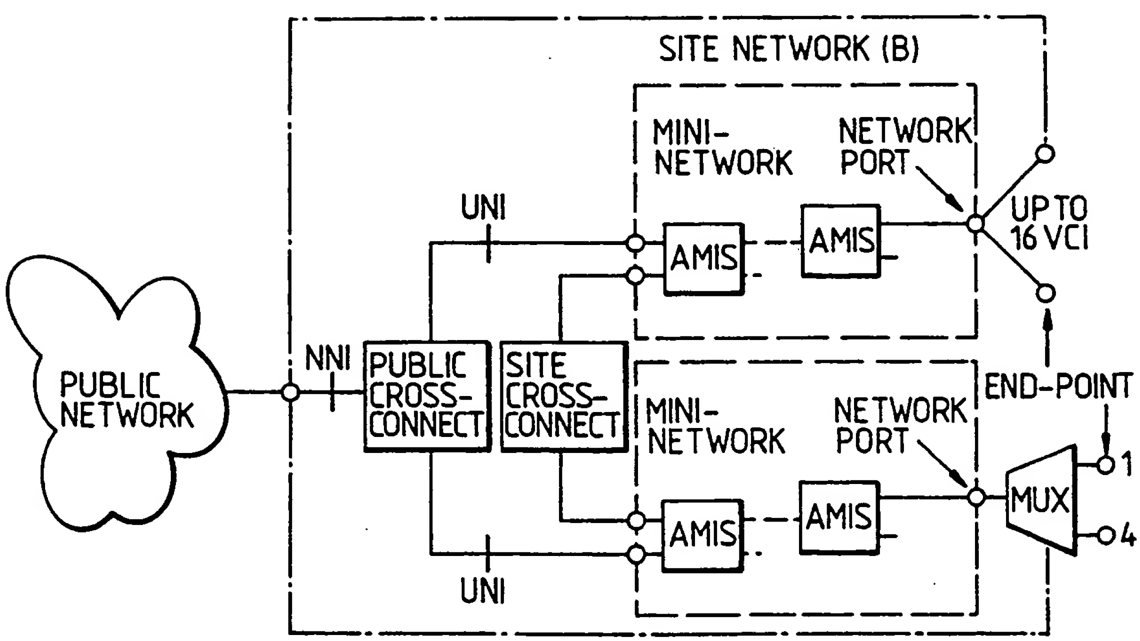

D-Mini-Net
IMPLICIT VALUES
S-Mini-Net
?
GFC
S-Port 2
S-Port 1
D-Port 2
D-Port 1
Mux. D/S
D-Port 2
D-Port 1
S-Mini-Net
S-Port 2
S-Port 1
Mux. D/S
DEST. SITE UNI PVC (B)
AMIS NETWORK ADDRESS

Fig.12.


SITE NETWORK (B)
MINI-NETWORK
NETWORK PORT
UNI
AMIS
AMIS
UP TO 16 VCI
PUBLIC NETWORK
NNI
PUBLIC CROSS-CONNECT
SITE CROSS-CONNECT
MINI-NETWORK
NETWORK PORT
END-POINT
AMIS
AMIS
MUX
1
4
UNI

2269724

ATM NETWORK ADDRESSING

A solution to the (layer 2) addressing of ports in a private, connectionless, Asynchronous Transfer Mode (ATM) (Cell-Relay) Virtual Private Network (VPN) with a moveable boundary between the Customer Premises Equipment (CPE) and the public network and a "seamless" interface between the two is described. The VPN provides a Direct-Connectionless service using single-cell datagrams in the CPE part and Permanent Virtual Channels (PVCs) in the public network part. The architecture of, and services provided by, a public network conforming to relevant international standards are in no way restricted by the needs of the private network.

Although the parts of the VPN implemented in the public network and on private sites use quite different infrastructures matching different environmental needs, the interface between the two can truly be described as "seamless"; this is in large part due to a very close match between the chosen private network address structure and the technique adopted for constructing addresses for PVCs on the User-Network Interfaces (UNI) and Network-Network Interfaces (NNI) in the public network.

The addressing capability of the ATM layer of the VPN is restricted by the standard ATM cell header size to 4,096 ports maximum; however, the header format also allows for the addition of 4-way multiplexers on terminal network ports.

Cells are transported free of any overhead in the information field and the majority of ports are expected to be adapted to higher layer protocols which include addressing, such as TCP/IP for Local Area Network (LAN) interconnect; the number of user terminals which may be served is therefore very large.

Early draft specifications are now beginning to emerge for Virtual Private Networks (VPNs) using ATM/Cell-Relay based on the use of Permanent Virtual Circuits/Channels (PVCs) in the public network and a movable boundary between the Customer Premises Equipment (CPE) and the public network, with a "seamless" interface between the two.

A PVC is a managed entity and each source port into the network must have "permanent" access to a PVC for every destination port it wishes to address. If, as is likely, every source port in the private network needs access to every destination port in the same network then the total number of PVCs which must be provided is the square of the number of sources/destinations which, for any non-trivial private network, is a very large number requiring due care in the structuring of the network.

The issue of addressing will, because of the restricted header size, dominate ATM VPN architectures more than any other, but draft specifications tend to say "addressing is for further study". The solution described optimises the private network addressing and then maps this solution onto public network PVCs; an architecture and addressing technique is described where the mapping is simple and unrestricting.

It is worth noting that, taking the public and customer premises components separately, because PVCs provide a "connectionless" service, the values in the Virtual Channel Identifier (VCI) and Virtual Path Identifier (VPI) fields of the ATM cell header are, in fact, layer 2 addresses.

The public network is, for all practical purposes, open ended; there must be no network size restriction imposed by the addressing mechanism.

Each site in the private network will be given a unique address carried in the VPI field (UNI format) in the upstream direction of a public network access bearer, to address the

destination site.

In the intervening public network routing is as normal for a virtual path using the NNI format. The VCI field is passed transparently across the public network.

In the downstream direction on the site bearer of the destination site, the VPI value used will be the source site address.

According to the present invention there is provided a corporate network using Asynchronous Transfer Mode (ATM) comprising two or more site networks linked by a public ATM network using Permanent Virtual Channels (PVCs), the said corporate network providing a connectionless service between any pair of terminal ports addressed using only the Virtual Path Identifier field (VPI) and the Virtual Channel Identifier field (VCI), of the CCITT recommended ATM cell format and where the full 48 octets of the Information field are transported between the terminal ports with no overhead imposed by the ATM layer of the network.

The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows a diagrammatic representation of a hypothetical public/private network;

Figure 2 shows the User-Network Interface Format for ATM cell addressing;

Figure 3 shows the Network-Network Interface Format for ATM cell addressing;

Figure 4 shows a diagrammatic view of a typical AMiS network;

Figure 5 shows a diagrammatic view of a balanced network;

Figure 6 shows address mapping used within the network of Figure 5;

Figure 7 shows a diagrammatic view of a network where a mix of small and medium sized networks occurs;

Figures 8 and 9 show the address mapping used within the network of Figure 7;

Figure 10 shows the address mapping used with a single network port;

Figure 11 shows a variant of the address mapping shown in

Figure 6 indicating the difficulties experienced where there is more than one mini-network;

Figure 12 shows a modification to the network to overcome the problem indicated in Figure 11.

Figure 1 illustrates two separate public network connections in a hypothetical network, Coventry to Beeston and Beeston to Poole.

The VPI and VCI values received are used in the customer premises equipment to identify the private network source site and the destination address in the destination site respectively, together with the source site source address. A more complete description of the addressing mechanism is given later.

Unlike a public network, a private network may have a defined size limit and advantages can be gained in reduced costs and complexity; a concept which takes advantage of this fact has been devised. The concept is referred to as AMiS (ATM Mini-Switches) and is the subject of Patent Application No. GB 9108824.5.

In the network, absolute addresses for all ports of the private network are allocated and the destination and source addresses are carried in the VPI and VCI fields respectively of each ATM cell using the NNI format. The maximum number of network ports which may be served is limited by the 12-bit VPI field size to 4,096; however this number can be expanded by the use of 4-way multiplexers on appropriate network ports. No overhead is carried in the Information Field of cells therefore adaption layer information, for example supporting TCP/IP datagrams for LAN interconnect, may use the accepted format without modification apart from Segmentation-And-Reassembly between packets and cells.

The four bit field used by a multiplexer, as referred to above, is divided into two 2-bit fields, one providing the destination port address of the multiplexer, the other providing the source port address of a distant source multiplexer.

The UNI and NNI formats for ATM cells are shown in Figures 2 and 3 below, together with the usage of the fields for AMiS addressing as described herein.

A diagram showing an example of a typical AMiS network is

shown in Figure 4. Two uses of the remaining four bits of the VCI field are shown; to provide source and destination addresses for a 4-way multiplexer, and to provide for up to 16 predefined or negotiated virtual channels (VCs) between a pair of network ports; when one end of the connection is a multiplexer the number of VCs served is reduced to four.

For a network covering several sites a part of the above model, including some of the switching, would be provided by the public network. With the method of public network addressing described in the previous section, cells are transported transparently; the private network is unaffected by the use of public network links except at the interface between the public network and the site CPE.

Because the destination address carried in the VPI field is an "absolute" address it is not translated in individual switches, but simply interpreted to an outgoing port on the switch and passed on unchanged.

Considering a balanced network where AMiS is mapped on to the public network which is the simplest case for a network where each site comprises one AMiS Mini-Network. The public network provides the cross-connect switching between the site networks as shown in Figure 5.

Within the site network the full header format is used, shown as on the left in Figure 6. On the public network access link the four bits used to identify the destination mini-network are replaced by the GFC field but both source and destination mini-network identities are implicit in the PVC identity.

Mappings at points A and B in Figure 5 are also shown in Figure 6.

The Destination Mini-Network address is used to identify the public network PVC at the UNI of the source mini-network and the Source Mini-Network address is used to identify the PVC at the destination mini-network. The format of the remaining fields is arranged to enable a general solution unaffected by the size of site network, as will be described below.

In the core network the 16 PVCs required by each site are

carried as 16 of a possible 256 using the NNI format. The rest of the header address fields are transported unchanged by the network.

One of the 16 destination site addresses will be the address of the source site and a site is not expected to need to address itself, thus this address may be redundant. The network requires at least one reserved VPI value for its own uses but if the site address is made to coincide with the reserved address then 16 sites may still be served. Since the reserved VPI value is fixed and the site address is variable a small VPI value translator is needed at the site interface.

In Figure 7 is shown a medium sized site comprising one Mini-Network (B) connected by the public network to a number of small sites each comprising a segment of a Mini-Network.

Two small sites (A1) and (A2) are shown on the left in Figure 7.

For this case the mapping of addresses is very similar to the earlier example. From A1 or A2 to B the mapping is as shown in Figure 8.

Note that the same cell header formats are used as earlier only the boundary where the public network takes an interest is changed.

Using the same general purpose cell formats a single network port can be handled by moving the public network boundary a further 4 bits. This implies extension beyond the limit of the VPI field into the Most Significant (MS) 4-bits of the VCI field.

A site which comprises more than one mini-network cannot be served by a single bearer because the available address space is too restricted; this fact is illustrated in Figure 9 for a variant of the first example.

The solution to this problem is separate local and public network cross-connects as shown in Figure 10.

The public network cross-connect has User Network interfaces on the downstream side. Because the UNI carry GFC they need to be incorporated into the public network management system; thus the public network cross-connect is likely to be owned by the public network operator although located on the customer site.

CLAIMS

1. A corporate network using Asynchronous Transfer Mode (ATM) comprising two or more site networks linked by a public ATM network using Permanent Virtual Channels (PVCs), the said corporate network providing a connectionless service between any pair of terminal ports addressed using only the Virtual Path Identifier field (VPI) and the Virtual Channel Identifier field (VCI) of the CCITT recommended ATM cell format and where the full 48 octets of the Information field are transported between the terminal ports with no overhead imposed by the ATM layer of the network.

2. A corporate network according to Claim 1 where the VPI and VCI fields at all terminal ports together carry the destination address and the source address for a communication and where the network is divided into sub-networks where each sub-network uses a part of the source and destination address to identify a terminal port within a sub-network and the remainder of the source and destination address is used to identify the sub-network.

3. A corporate network according to Claim 2 where the site network comprises one or more ATM switches and where each switch input interprets the destination address carried by each cell by means of a look-up table providing the identity of an outgoing port on the switch.

4. A corporate network according to Claim 2 where one or more site networks comprise a single terminal port.

5. A corporate network according to Claim 3 or 4 where the network comprises a single site network.

6. A corporate network according to Claim 3 or 4 comprising two or more site networks interconnected by PVCs carried by the public network and where a PVC is allocated in the public network to connect each site to every other site of the corporate network and where the VPI and VCI fields of cells in the public network access bearer leaving a site carry the destination and source addresses of the corporate network less the part of the source address which identifies the source sub-network and where the VPI and VCI fields of

cells in the public network access bearer arriving at a site carry the destination and source addresses of the corporate network less the part of the destination address which identifies the destination site sub-network. By this means and with a field of at least four bits to identify the sub-network the VPI field on the access bearer is reduced from 12 bits to 8 bits in order to carry the Generic Flow Control (GFC) field for the User Network Interface (UNI).

7. A corporate network according to Claim 6 where one or more of the site networks comprise a single sub-network.

8. A corporate network according to Claim 6 where two or more of the site networks each comprise a part of a sub-network and where two or more of the said part sub-networks are linked by public network PVCs to form a single sub-network.

9. A corporate network according to Claim 7 or 8 where any remaining and unused bits of the combined VPI and VCI fields are split into two equally sized fields one of which provides the end-point address for a multiplexer connected to the destination terminal port of the network and the other provides the end-point address for a multiplexer connected to the source terminal port.

10. A corporate network according to Claim 7 or 8 where any remaining and unused bits of the combined VPI and VCI fields are used to identify one of 2^n virtual channel between two terminal ports where "n" is the number of bits remaining.

11. A corporate network according to Claim 7 or 8 where any remaining unused bits of the combined VPI and VCI fields are split into two equally sized fields which provide destination and source identifiers to the public network for access to one of 2^n separate corporate networks.

12. A corporate network, substantially as hereinbefore described, with reference to and as illustrated in the accompanying drawings.

Examiner's report to the Comptroller under Section 17 (The Search report)	GB 9316417.6
Relevant Technical Fields (i) UK Cl (Ed.L) H4K (KTK, KY4, KY4D, KY4D2, KY4D4, KY4D6, KY4D8, KY4D10T, KY4D14) (ii) Int Cl (Ed.5) H04L (12/50) H04Q	Search Examiner MR S J L REES Date of completion of Search 5 NOVEMBER 1993
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASES: WPI	Documents considered relevant following a search in respect of Claims :- 1-12

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages	Relevant to claim(s)
A, P	GB 2253118 A (ROKE MANOR) whole document	1
A, E	EP 0524316 A1 (FUJITSU) whole document	1

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